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OCEANOGRAPHIC CONDITIONS IN NAFO SUBDIVISIONS 3Pn AND 3Ps DURING 1995 AND 1996 WITH COMPARISONS TO THE LONG-TERM (1961-1990) AVERAGE

by

Eugene Colbourne

Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Newfoundland, Canada A1C 5X1

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Résumé

Les données océanographiques obtenues pour les divisions 3Pn et 3Ps de l'OPANO en 1995 et 1996 sont examinées et comparées à la moyenne à long terme (1961-1990). Les données sont présentées de façons diverses: sous forme de transects verticaux coupant les plus importants bancs et chenaux, de cartes horizontales des températures au fond de la zone examinée, et de séries chronologiques des anomalies de température à des profondeurs océanographiques standards. L'analyse montre que les températures anormalement faibles notées sur les bancs au milieu des années 1980 se sont modérément redressées en certains endroits au début des années 1990, mais que d'importantes zones à température inférieure à la normale ont subsisté jusqu'en 1995, notamment dans certaines parties de l'est du banc St. Pierre et dans la baie Placentia. Le relevé de printemps de 1996 indique cependant que les conditions reviennent à la normale. L'examen des températures dans la gamme de profondeur des 200 à 400 m, le long des bords du chenal Laurentien et au sud-ouest du Grand Banc ne permet pas de déceler de variations interannuelles appréciables, mais l'on note dans cette zone d'importantes variations spatiales, de l'ordre de 2,5 °C, à 200 m de profondeur.

ABSTRACT

Oceanographic data from NAFO subdivisions 3Pn and 3Ps during 1995 and 1996 are examined and compared to the long-term (1961-1990) average. The data is presented in several ways, as vertical transects across the major banks and channels, horizontal bottom temperature maps of the area and as a time series of temperature anomalies at standard oceanographic depths. The analysis indicates the anomalous cold period that started on the banks in the mid 1980s has moderated in some areas during the early 1990s but large areas with below normal temperatures continued into 1995, particularly on the eastern portions of St. Pierre Bank and the Placentia Bay area. Data from the 1996 spring survey, however, show conditions returning to more normal values. An examination of temperatures in the 200-400 m depth range along the edges of the Laurentian Channel and southwestern Grand Bank did not reveal any significant interannual variations, however, the region experiences large spatial variations of the order of 2.5°C at 200 m depth.

INTRODUCTION

This report summarizes oceanographic conditions in NAFO subdivisions 3Pn and 3Ps (Fig. 1) during 1995 and 1996 with a comparison to the long-term mean. The mean base period has been defined as the 30-year period from 1961-1990 in accordance with the convention of the World Meteorological Organization and recommendations from NAFO Scientific Council. A similar report was published for data from 1990-1994 referenced to a 1915-1993 average (Colbourne 1994). These reports rely mainly on temperature data collected during each fishing set by the Canadian groundfish assessment surveys conducted during February, March and April since 1973. The fishing set positions for the 1995 and 1996 surveys are shown in Fig. 2. Since the winter of 1990, water temperatures on groundfish assessment surveys were measured, for the most part, using trawl-mounted Seabird 19 CTD systems; before that XBTs were the primary instrument. In addition, all available historical data are included in the analysis.

The vertical distribution of temperature is examined along a transect from near shore at Rose Blanche on the south coast of Newfoundland in a southeasterly direction crossing Burgeo Bank, Hermitage Channel and St. Pierre Bank and offshore to the edge of the continental shelf on the southwestern Grand Bank (Fig. 1, Box A). In addition, spatially-averaged time series of temperature anomalies mainly on St. Pierre Bank (Fig. 1, Box B) are examined together with bottom temperatures over the entire 3Pn and 3Ps area.

The general circulation in the 3Ps region consists of modified Labrador current water, the inshore branch of which flows through the Avalon Channel around the Avalon Peninsula westward north of St. Pierre Bank and to the south between Green Bank and Whale Bank. Additionally, part of the offshore branch of the Labrador current flows around the tail of the Grand Bank, westward along the continental slope where it is influenced by the Gulf Stream and slope waters, to the Laurentian Channel and into the Gulf of St. Lawrence.

Since the early 1970s, the oceanographic, meteorological, and ice conditions of the Northwest Atlantic have been dominated by three anomalous periods: early 1970s, mid 1980s and the early 1990s. During these periods strong positive winter North Atlantic

Oscillation (NAO) index anomalies were mainly responsible for colder than normal air temperatures over the Northwest Atlantic resulting in increased ice cover and eventually colder and fresher than normal oceanographic conditions over most of the continental shelf in Atlantic Canada (Colbourne et al. 1994; Drinkwater et al. 1992; Narayanan et al. 1994). The extent to which these oceanographic anomalies may have influenced the 3Ps region is documented by several studies (Hutchings and Myers 1994; Moguedet and Mahe 1991; Battaglia and Poulard 1987; Forest and Poulard 1981; and Colbourne 1994).

VERTICAL TEMPERATURE FIELD

The vertical section (depth versus horizontal distance from the shore along the transect) of the average temperature field for April based on the historical data is shown in Fig. 3. No attempts were made to adjust this average for possible temporal or spatial biasing arising from variations in the number of observations within the time interval or within the area. An examination of the data indicates that the observations are well distributed geographically across the complete transect, however temporally, most of the data have been collected since the early 1970s.

The average upper layer temperature for April from near shore at Rose Blanche on the south coast of Newfoundland over Burgeo Bank and Hermitage Channel is about 1.0°C. Over St. Pierre Bank the temperature ranges from 1.0°C near the bottom to 2.0°C near the surface and beyond the shelf edge in the upper 100 m of the water column. In the deeper water of Burgeo and Hermitage Channels and on the continental slope region the temperature ranges from 2.0°C at approximately 125 m depth to 5.0 to 6.0°C near the bottom. Near the edge of the continental shelf on the southwestern Grand Bank the temperature field is marked by a strong front separating the warmer slope water from the Labrador current water over St. Pierre Bank. In this region, temperatures increase from 1.0°C at about 100 m depth to between 5.0 to 6.0°C at about 175 m depth, a temperature gradient of 1.0°C per 15 m depth change (Fig. 3).

During April 1995 (Fig. 4), temperatures ranged from 0.5 to 1.0°C near the coast and over St. Pierre Bank to 0.0 to 7.0°C at the edge of the shelf, generally about 1.0°C below average on the Bank and up to 3.0°C above normal in the upper water column at the shelf edge. In April 1996, upper layer temperatures were slightly cooler over Burgeo Bank and Hermitage channel at about 0.75°C about 0.25°C below average. Over St. Pierre Bank temperatures were warmer than in 1995 but still slightly below average. Deep water temperatures on the continental slope were near average at about 6.0 to 7.0°C both in 1995 and 1996.

BOTTOM TEMPERATURES

The average April bottom temperatures (Fig. 5) range from 5.0°C in the Laurentian, Burgeo and Hermitage channels to about 3.0 to 4.0°C on Rose Blanche and Burgeo banks and from 0.0°C on the eastern side of St. Pierre Bank to 2.0 to 3.0°C on the western side. In general, the bottom isotherms follow the bathymetry around the Laurentian Channel and the Southwestern Grand Bank decreasing from 2.0°C at 200 m depth to 5.0°C in the deeper

water. These maps were contoured from all available bottom of the profile temperature measurements in the period 1961-1990, rejecting values for which the profile depths were not within 10% of the water depth.

In April 1995, temperatures were generally below average over most of Burgeo and St. Pierre banks, particularly on the eastern side of St. Pierre Bank where temperatures were about 1.0°C below average. During April 1996, temperatures appear to have moderated to near normal values over most areas. It appears that the moderating conditions on the Newfoundland Shelf during the last two years have started to influence conditions in the 3ps region. The large negative anomaly over the eastern side of St. Pierre Bank, present since 1991, has disappeared (Fig. 6).

TEMPORAL ANOMALIES IN TEMPERATURE

To examine the interannual variations in temperature during the last several decades the historical data set for region B in Fig. 1 was examined. This region encompasses most of St. Pierre Bank in a depth range of 0 to 75 m. The historical data set for this area for all years were sorted by day of the year to determine the seasonal cycle. Following the general methods of Akenhead (1987) and Myers et al. (1990), the seasonal cycle in the temperature field at selected water depths was determined by fitting a least-squares regression to the mean and a sum of 4 sine and cosine pairs representing 4 harmonics.

Time series of temperature anomalies were formed by taking each observation and subtracting the least squares fitted value of the seasonal cycle for the same day of the year. Observations made on the same day within the same area were averaged. Unlike the time series at fixed points (eg. Station 27), these time series are based on a smaller data set distributed over a wider geographical area, hence the anomalies show both spatial and temporal variations (Fig. 7).

The time series of temperature anomalies at standard depths of 0, 20, 50 and 75 m (Fig. 7) are characterized by very large high frequency variations. The low passed filtered time series show variations with amplitudes ranging from $\pm$ 1.0°C and with periods between 5 to 10 years with some higher frequency variations in the upper water column. The cold periods of the mid 1970s and the mid 1980s are coincident with severe meteorological and ice conditions in the Northwest Atlantic and colder and fresher oceanographic anomalies over most of the Canadian continental shelf (Findlay and Deptuch-Stapf 1991). The cold period beginning in 1984 when overall temperatures decreased by up to 1.0°C continued below normal until 1990. During 1991, temperatures moderated over the top 50 m of the water column but remained generally below average at 75 m depth. Since 1992, the temperatures anomalies fluctuated above and below zero, particularly in the upper water column, but remained mostly negative near the bottom at 75 m depth.

To examine the variability in deeper water along the edge of the Laurentian Channel and the southwestern Grand Bank temperature time series were constructed at depths of 200, 300, and 400 m (Fig. 8). The annual cycle at these depths was not statistically significant. The time series are characterized by large high frequency variations which decrease with depth. At 200 m depth the temperature variations are of the order of 2.5°C about a mean of

near 6.0°C and at 400 m depth the variations decrease to around 1.0°C around a mean of about 5.0°C. Most of these variations occur during short time scales (of the order of a typical survey) as indicated by the vertical lines in the plots and are due to spatial variations along the edges of the banks. There is no indication of any significant interannual variations in the deep water temperatures in the 3Ps region.

SUMMARY

Time series of temperature anomalies in the 3Ps St. Pierre Bank area show anomalous cold periods in the mid 1970s and since the mid 1980s, similar to conditions on the continental shelf along the east coast of Newfoundland. The most recent cold period, which started around 1984, continued to the early 1990s with temperatures up to 1.0 °C below average over all depths and up to 2.0 °C below the warmer temperatures of the late 1970s and early 1980s in the surface layers. Temperatures in deeper water off the banks show no significant changes. Since 1991, temperatures have moderated somewhat in some areas from the lows experienced from the mid to late 1980s and 1990 but large spatial areas with negative temperature anomalies continued into the spring of 1995, particularly on the eastern portion of St. Pierre Bank. The results from the 1996 spring survey show conditions returning to more normal values.

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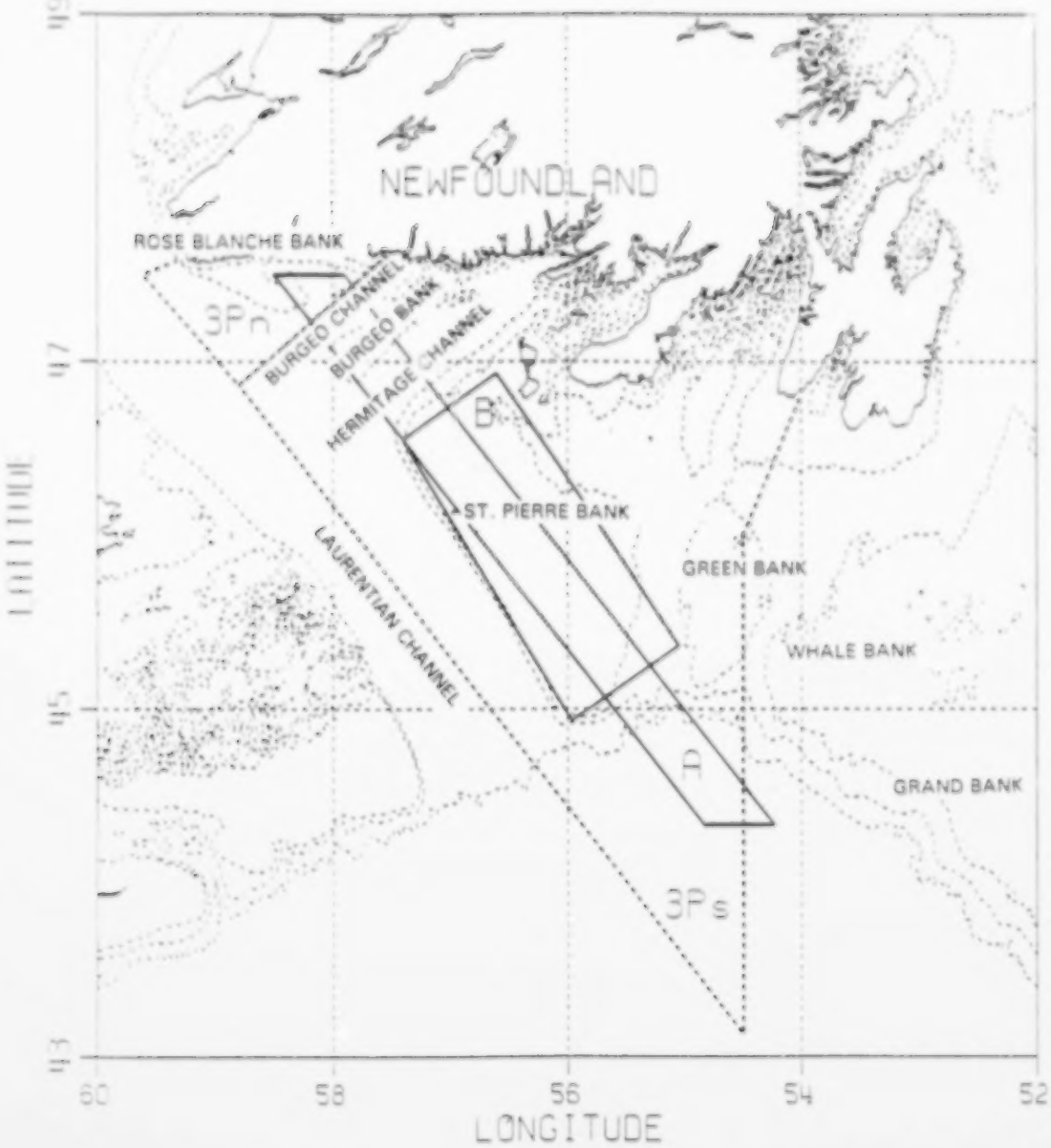

Fig. 1. Location map showing the 3Pn and 3Ps subdivisions and the areas A and B from which data were examined. The bathymetry lines are 100, 200 and 1000 m.

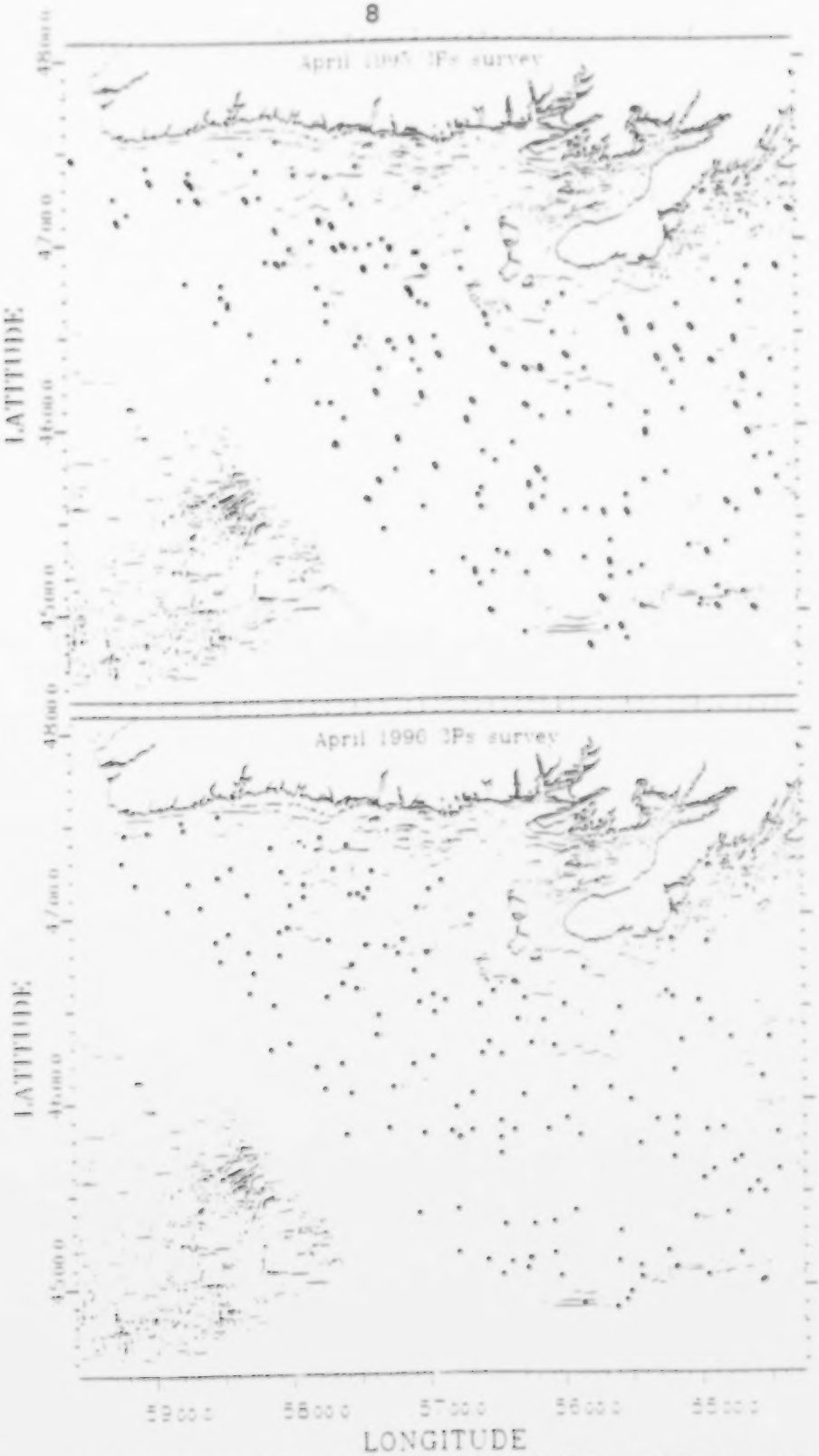

Fig. 2. Location map showing the positions of all sets where oceanographic measurements were made subdivisions 3Pn and 3Ps during 1995 and 1996. The bathymetry lines are 100, 200 and 300 m.

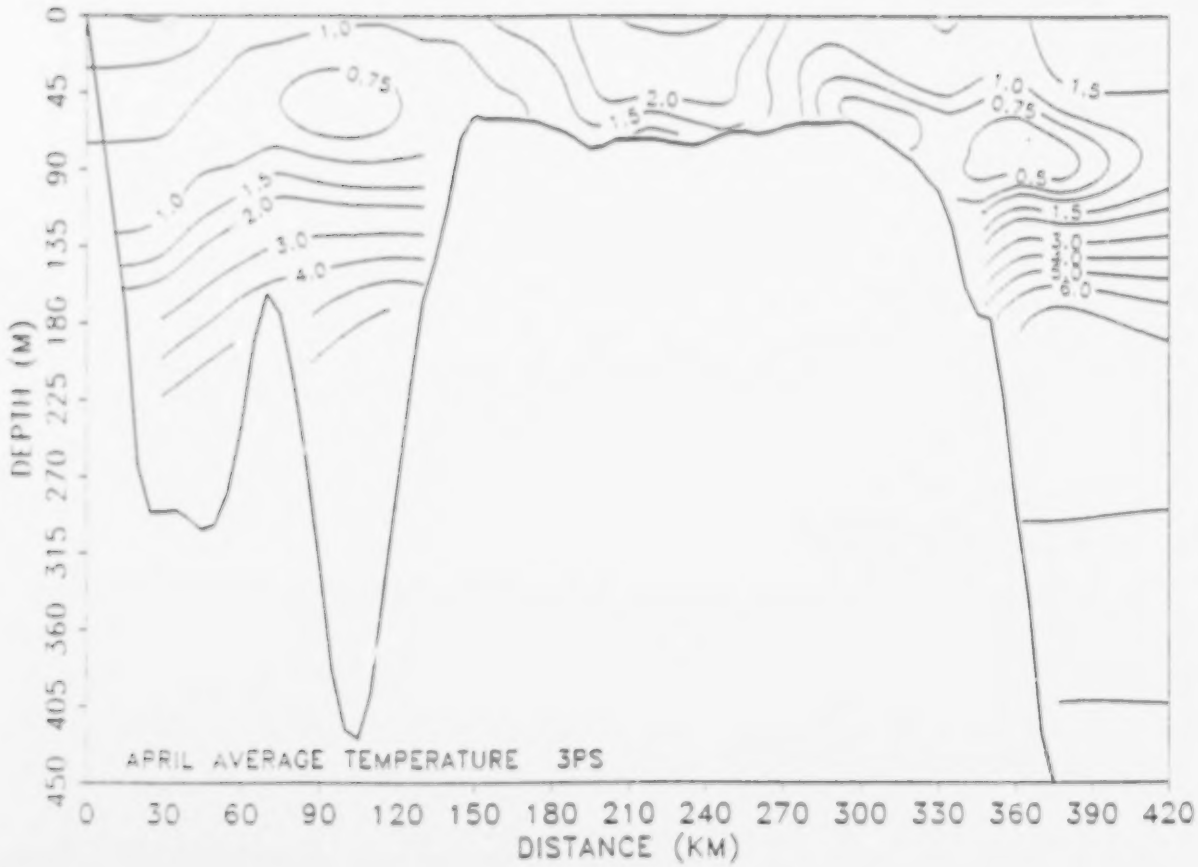

Fig. 3. The April average temperature along the transect shown in Fig. 1 for NAFO subdivisions 3Pn and 3Ps based on the historical data from 1961 to 1990.

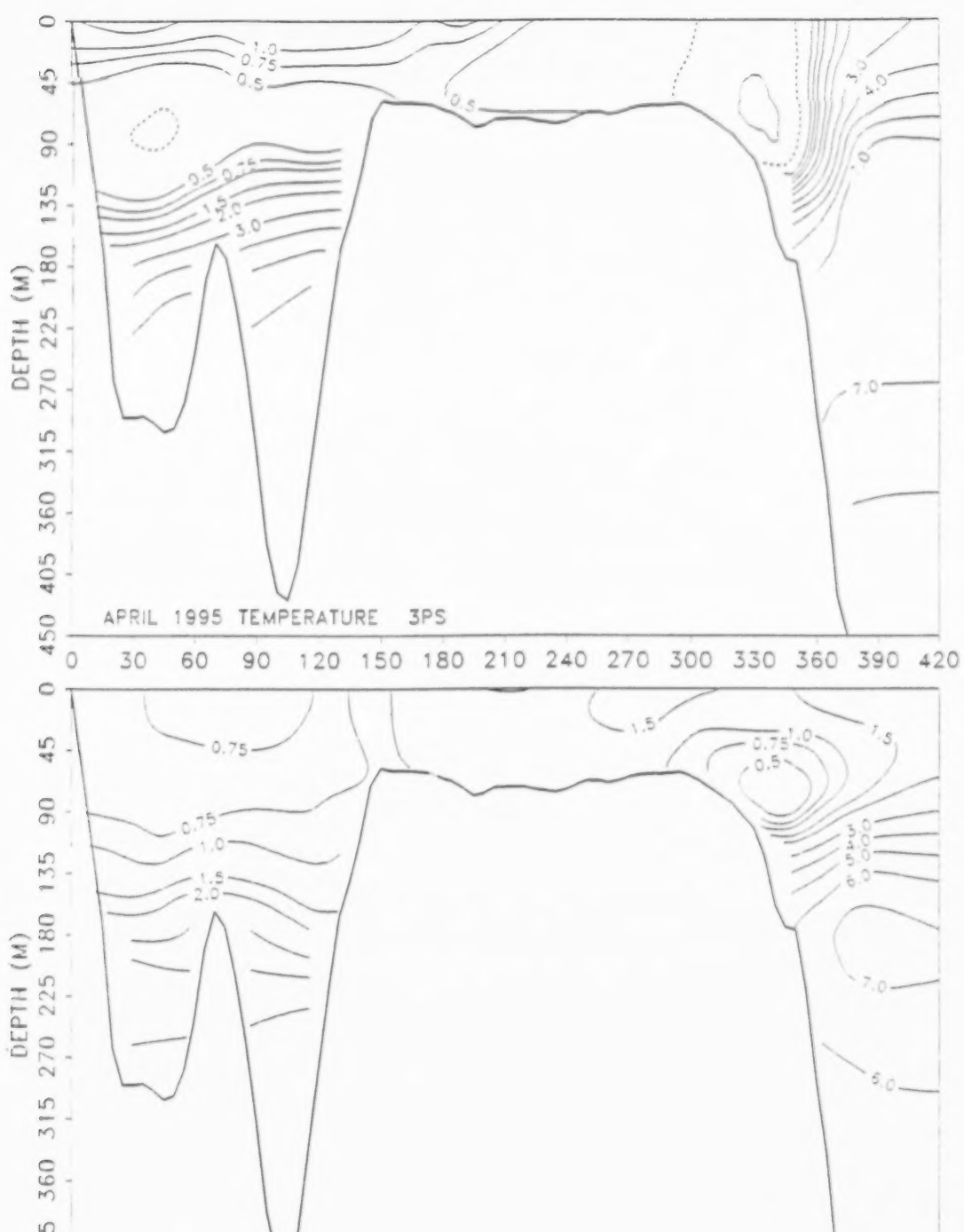

Fig. 4. The 1995 and 1996 April temperature along the transect shown in Fig. 1 for NAFO subdivisions 3Pn and 3Ps.

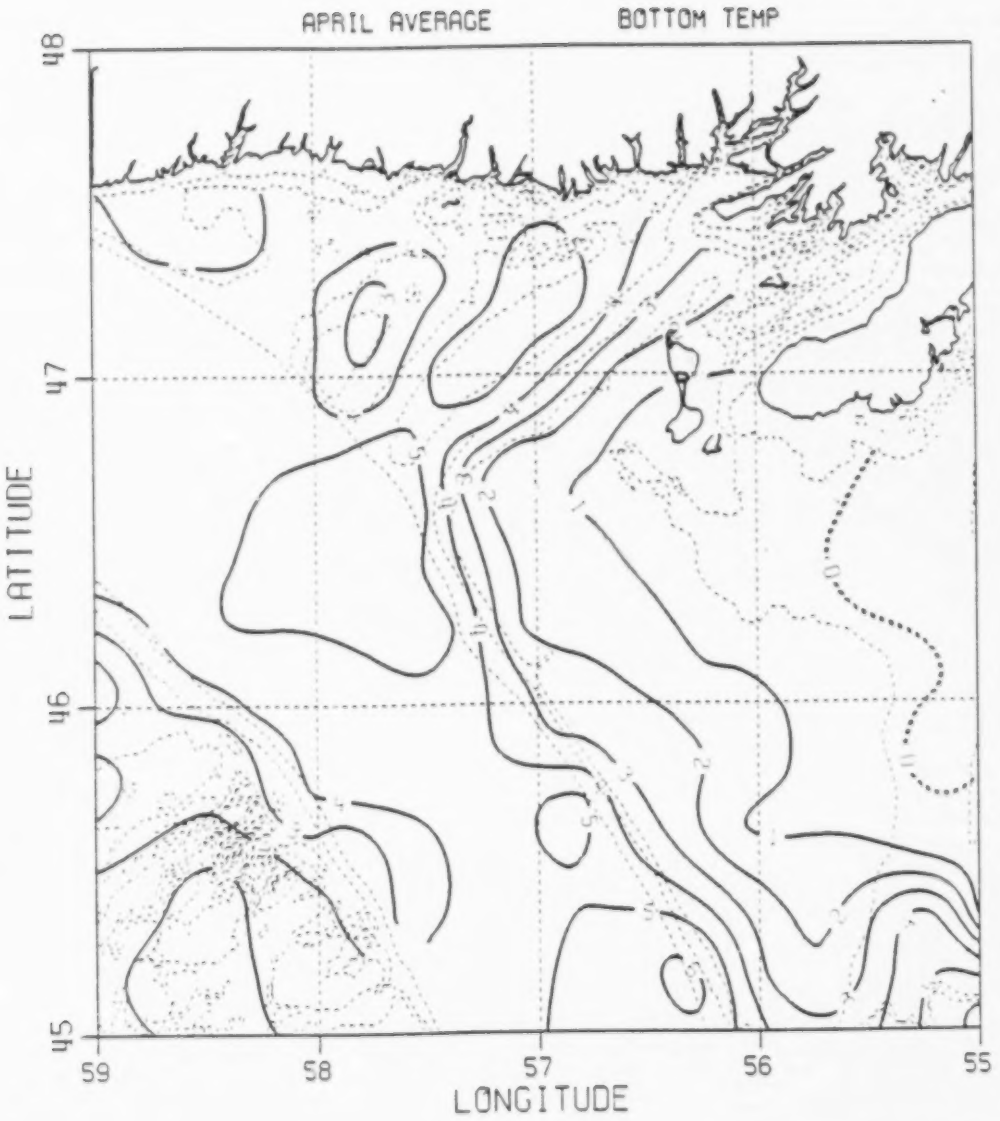

Fig. 5. The April average bottom temperature in NAFO subdivisions 3Pn and 3Ps.

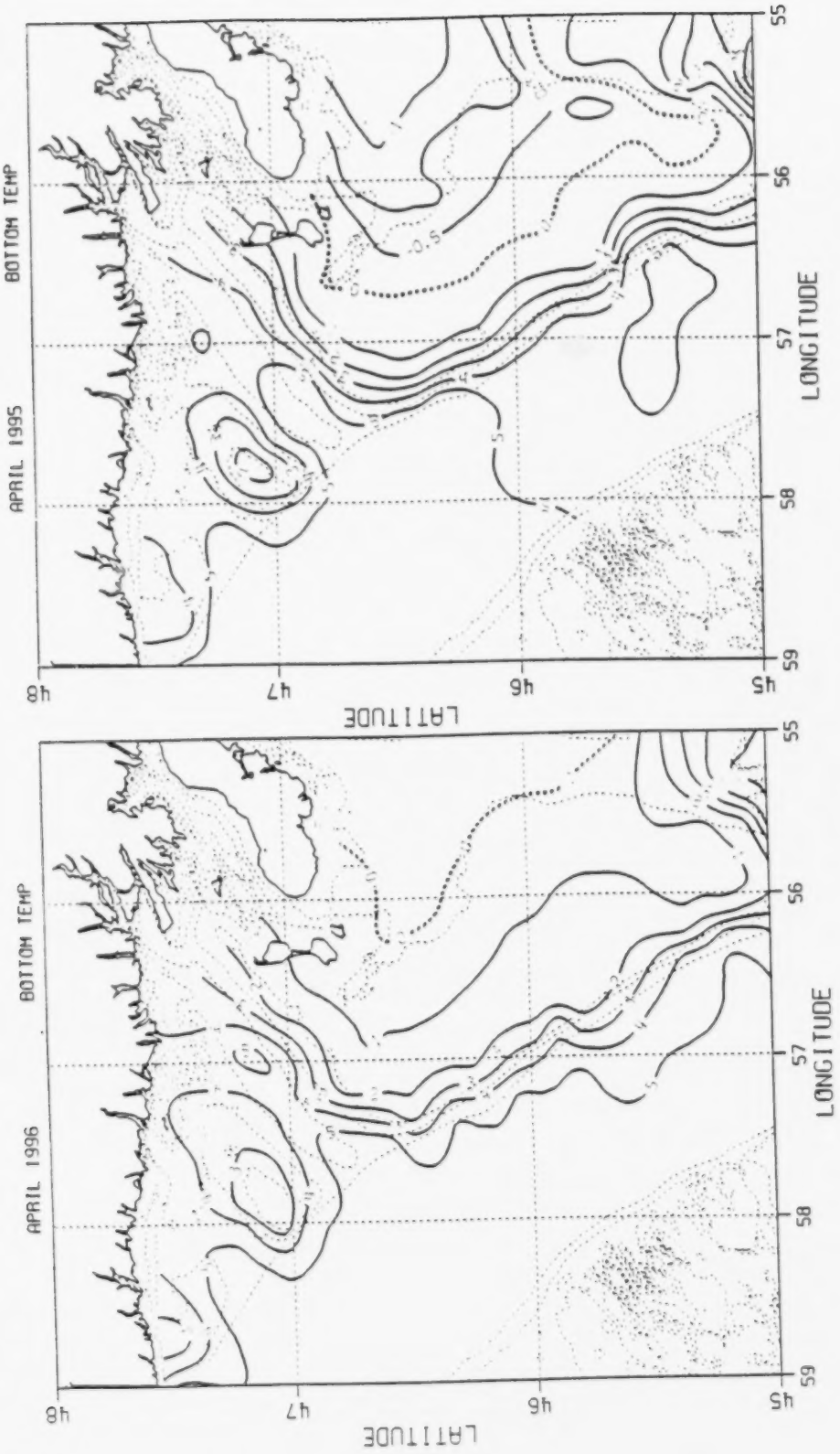

Fig. 6. The 1995 and 1996 April bottom temperature in NAFO subdivisions 3Pn and 3Ps.

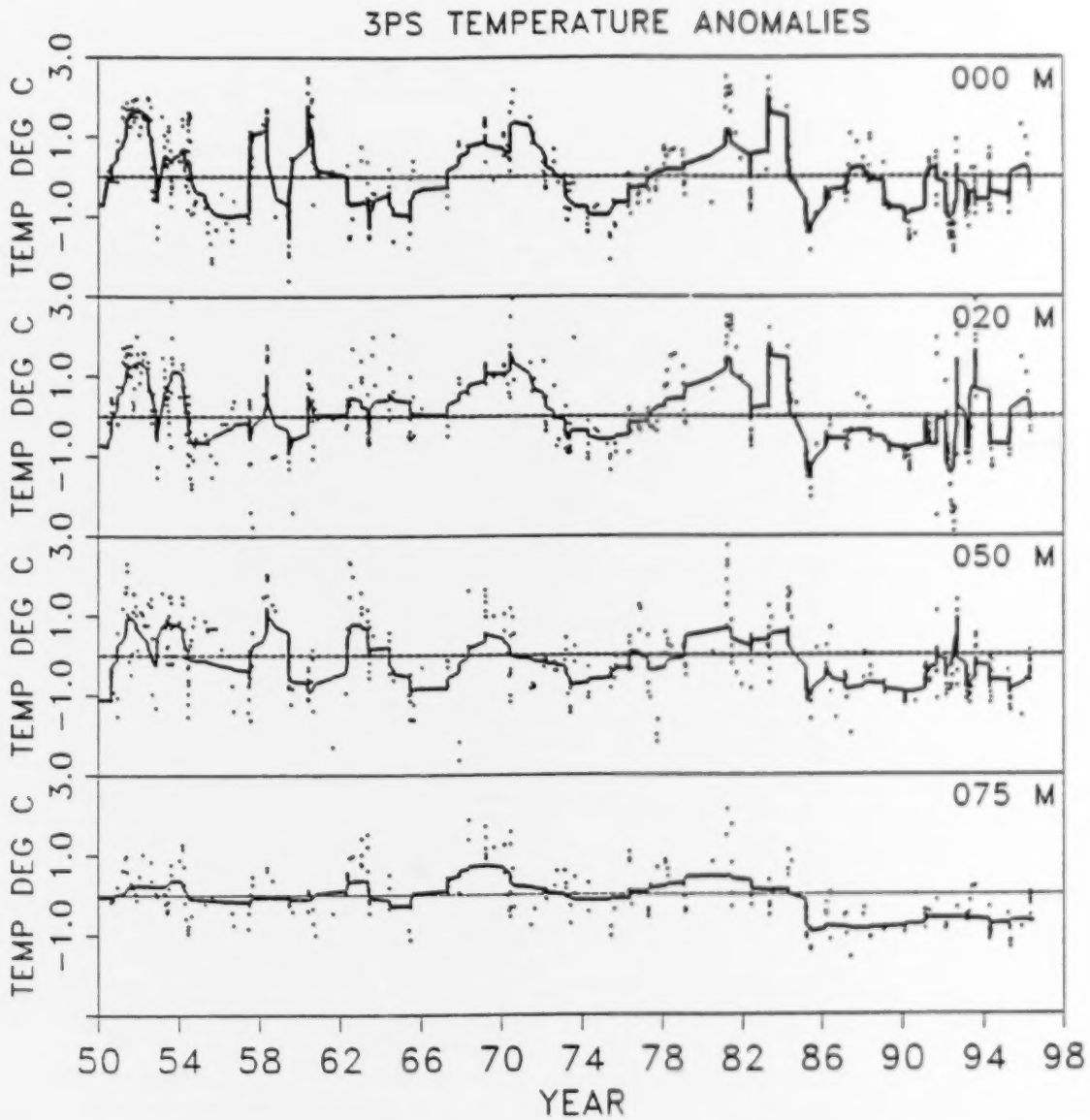

Fig. 7. Temperature anomaly time series at standard depths of 0, 20, 50 and 75 m for box B in Fig. 1. The heavy solid line represents the low passed filtered temperature anomalies.

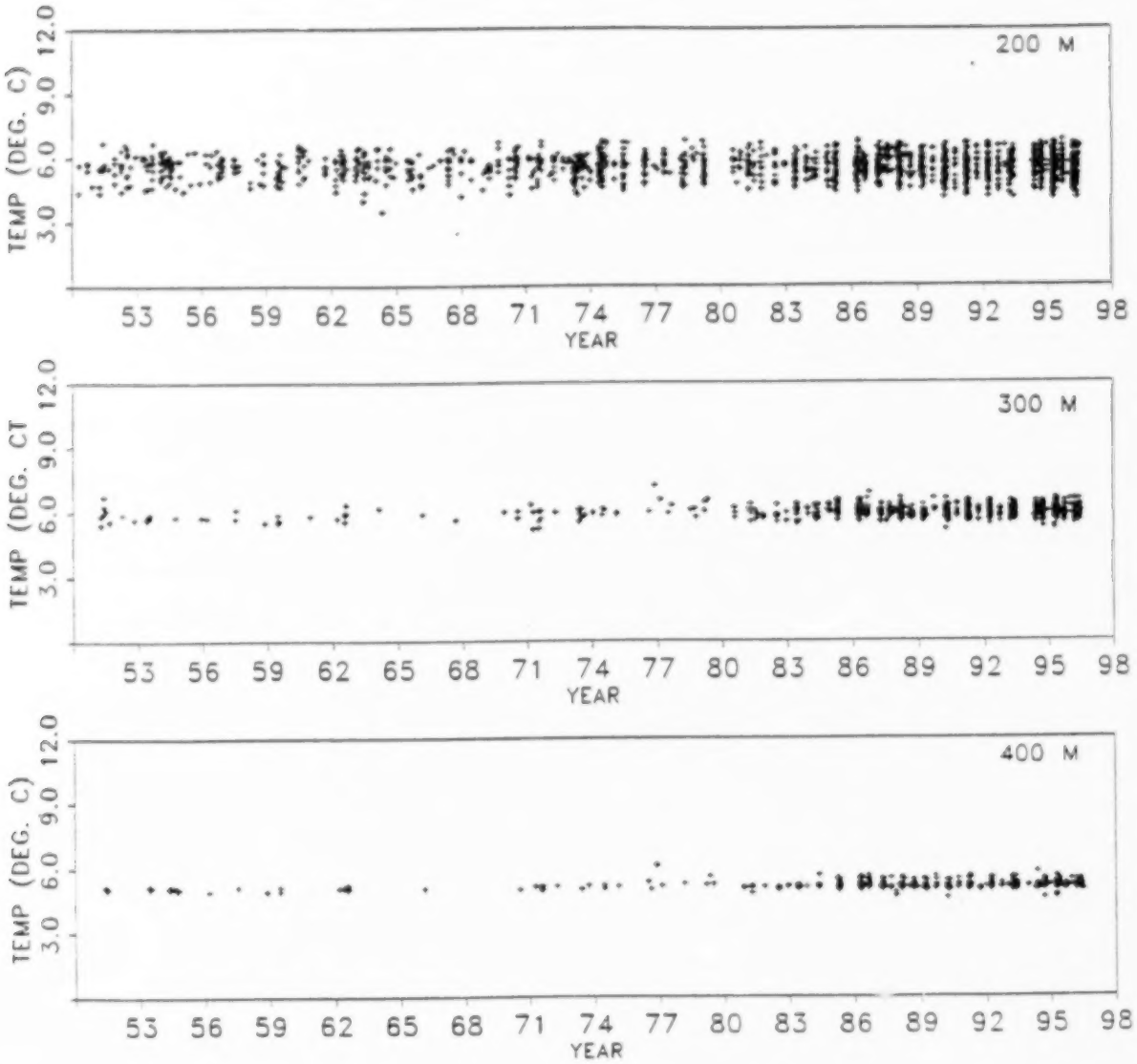

Fig. 8. Temperature time series at depths of 200, 300, and 400 m for the 3Ps region.